

HARBOR AT DELAWARE BREAKWATER.

LETTER

FROM

THE SECRETARY OF WAR,

TRANSMITTING

Report upon the harbor at the Delaware Breakwater.

FEBRUARY 15, 1879.—Referred to the Committee on Commerce and ordered to be printed.

WAR DEPARTMENT,
Washington City, February 15, 1879.

The Secretary of War has the honor to transmit to the House of Representatives, for the consideration of the Committee on Commerce, a letter from the Chief of Engineers, of the 14th instant, submitting report of a Board of Engineers upon the deterioration of the harbor at the Delaware Breakwater, and concurring in the views and recommendations therein set forth.

GEO. W. McCRARY,
Secretary of War.

The SPEAKER of the House of Representatives.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 14, 1879.

SIR: In view of the present condition of the harbor at the Delaware Breakwater and the deterioration it has undergone, which is still in progress, and may at no distant day render it useless, except for the smaller class of vessels, I have the honor to submit herewith a copy of a report from a Board of Engineer Officers, to which the subject was referred by this office for its views and recommendations upon the questions involved in the preservation of the harbor.

The board recommends, as a possible remedy, the closure of the gap existing between the breakwater proper and its adjoining ice-breaker, which it is believed will, to a greater or less extent, check further deposits within the harbor and remove those existing on the shoals in its vicinity, and will increase the protected area of anchorage nearly four-fold.

The cost of this cannot be precisely estimated without further study of the details of the work, but it is estimated at less than \$600,000; and

the board, believing that the necessity of giving full efficiency to this great harbor of refuge is urgent, recommend an immediate appropriation of \$150,000.

Fully concurring in the views and recommendations of the board, I beg leave to suggest that, should it meet with your approval, this report be transmitted to Congress.

I also submit herewith a copy of the report of Capt. William Ludlow, Corps of Engineers, to which allusion is made in the report of the board.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Acting Chief of Engineers.

Hon. GEO. W. McCRARY,
Secretary of War.

OBSTRUCTIONS IN THE HARBOR OF DELAWARE BREAKWATER.

REPORT OF BOARD OF ENGINEERS FOR FORTIFICATIONS.

OFFICE BOARD OF ENGINEERS FOR FORTIFICATIONS, *New York, February 8, 1879.*

GENERAL: The Board of Engineers for Fortifications, with Col. J. N. Macomb, Corps of Engineers, as associate member, to whom was referred, by your letter of June 3, 1878, the subject of the growing obstructions in the harbor of the Delaware Breakwater, with instructions to examine into the remedies therefor suggested by Capt. William Ludlow, Corps of Engineers, have the honor to submit the following report:

Finding some further information touching the tidal currents in the harbor at Delaware Breakwater and vicinity desirable, a survey was ordered; the results of which were laid before the board in December, 1878.

Having fully considered these results, and the maps and charts showing the condition of this harbor of refuge from time to time since its creation, as well as the various reports and discussions connected therewith, we are of the opinion that the most prudent course in relation thereto would be to close the gap between the breakwater and the ice-breaker, and thus greatly increase the extent of protected area for the anchorage of vessels.

The ice-breaker and breakwater, which are now separated by an open space of about one-quarter of a mile in extent, would then form a continuous mole, and the protected area for anchorage would be increased nearly fourfold.

In making the above recommendation, the board refers to the fact that either the closure of the gap or the covering of it by an exterior work (a much more costly operation) has been recommended in every report since 1836, whether by boards or individual officers; the majority of opinions being decidedly in favor of the closure. The present condition of the harbor and the observations as to the progressive deterioration it has undergone show that it will soon be useless, except for the smaller class of vessels, unless some remedial steps be taken to check further deposits and to remove those now existing on the shoals in the vicinity of the breakwater. It is expected that the closure recommended will produce

both these effects to a greater or less extent. Until the results of such closure be determined, we deem it premature to discuss the other projects set forth in Captain Ludlow's letter for connecting the ice-breaker with the shore, or for shore protection of Cape Henlopen, as these works may prove unnecessary. At any rate, their extent and character, if required at all, will be understood when the closure of the gap in the breakwater has been tried.

We estimate the cost of closure of the gap as follows:

50,000 cubic yards riprap stone, at \$3.....	\$150,000
25,000 cubic yards dimension stone, at \$18.....	450,000
	<hr/> 600,000

The plan of construction being to build up from the bottom with riprap stone to 12 feet below low tide; then to 12 feet above low tide a wall with, say, 30-foot base and 12-foot thickness at top, with very large quarried dimension stone, or with concrete. It is believed that a further study of details of such a work will show that the cost will fall considerably within the amount of above estimate.

Believing that the necessity of giving full efficiency to this great harbor of refuge is urgent, we recommend an immediate appropriation of \$150,000.

Respectfully submitted.

J. G. BARNARD,
Colonel of Engineers, and Bvt. Maj. Gen'l.

J. N. MACOMB,
Colonel of Engineers.

Z. B. TOWER,
Colonel of Engineers, Bvt. Maj. Gen'l.

H. G. WRIGHT,
Lieutenant-Colonel of Engineers, Bvt. Maj. Gen'l.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

NOTE.—The papers and drawings referred to the board in connection with this subject are returned herewith.

REPORT OF CAPT. WILLIAM LUDLOW, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Philadelphia, May 15, 1878.

COLONEL: In accordance with the instructions given in your indorsement of May 2 on the paper herewith returned, I have the honor to submit the following report on the condition of the Delaware Breakwater Harbor, as shown by my survey of November, 1877.

The chart of this survey has been submitted; but in order to show clearly the changes that have taken place in the harbor since its construction, I have prepared the accompanying comparative chart, carefully compiled from tracings of the original maps in each case, and believed accurately to represent them on a common scale of $\frac{1}{3600}$.

The survey of 1828, by Lieutenant Sherburne, U. S. N., previous to the commencement of the works, is that from which the positions of

the ice-breaker and breakwater were designed. That of 1842 was made under direction of Major Bache, then in charge of the construction of the harbor; that of 1863 by the Coast Survey, and that of 1877 by myself in November last.

On Major Bache's chart the plane of reference is that of extreme low-water of spring tides; the high-water line, that attained by extreme high-water of spring tides.

The curves of the other charts are referred to the usual planes of reference, viz, those of mean high and mean low water.

Making allowance for this difference, which is not now susceptible of correction—and in fact is not material when understood—it appears from a comparison of the relative positions of the several sets of curves that the changes indicated have been in progress constantly, though not uniformly, during the entire period of forty-nine years from 1828 to 1877.

Though not in themselves specially remarkable in character, nor even unusual in extent, these changes are both significant and important, when considered in relation to the harbor of refuge which they affect. It would seem also that the period during which the recorded alterations have been progressing is sufficient not only to show the tendency of the forces at work, but to justify an anticipation of their future action, and to suggest the remedial agencies that should be applied to counteract those that have produced or threaten injury.

I shall endeavor to present such views as I find justified by a careful consideration of the subject, supplemented by my personal observation during last season's operations on the iron pier, from May to November.

The general effects may be set down as two in number, viz:

First. The advance northward and westward of the point of the cape.

Second. The decrease in depth of the anchorage sheltered by the works.

As these are believed to be distinct in character, and due to measurably independent causes, they will be considered separately.

Referring to the chart and comparing the lines of 1828 and 1877, the high-water mark on the sea-beach is seen to have encroached upon the land for an average width of about 500 feet to as great a distance southward as the curves enable us to trace the action. The material thus eroded from the outer shore has been carried northward, and mainly deposited at the point of the cape, but partly swept along the inner beach.

The result has been that the cape has projected itself in a general north-northwest direction for a distance of about 750 feet, so that the present high-water mark lies where Lieutenant Sherburne, U. S. N., in 1828, found "no bottom" at 12 fathoms.

The fathom contours have made a corresponding advance, and, in addition, a considerable filling has taken place along the shoal to the westward of the cape.

About 500 feet east of the iron pier is a neutral point, where the high-water lines all unite, the fathom curves in front of this point exhibiting also a remarkable tendency to stability. The filling, therefore, due to the movement at the cape terminates here. The causes producing this action are susceptible of the following explanation: The ebb tides, emerging from the bay with an off-shore set, have little or no effect upon the outer beach, which is also protected in a great measure from the full action of northeast storms by the shoal called the "Hen and Chickens," stretching southeastwardly from the cape for about 4 miles.

On the other hand, the flood-tides impinge upon the shore with a northwestwardly inclination, and are powerfully aided in their action by the south and southeast winds, against which no barrier exists.

The result of this inequality of forces is seen in the erosion of the beach and the transportation northward of the sands.

The deflection of the ebb-tide by the breakwater and the escape of a large portion of its current eastwardly through the "Gap" have hitherto prevented its interference with this process; but it would seem that as the cape has now passed considerably beyond the line of the breakwater prolonged, its further progress should soon be arrested.

A rough comparison of the deposits between 1863 and 1877 with those between 1828 and 1863 encourages this supposition, for the ratio is only about one-third that of the intervals in years.

It is to be observed, however, that although the progress northward of the cape may be checked, the deposit along the inner beach will still continue, though in diminished amounts, unless otherwise counteracted.

The second change in the harbor is, however, vastly more important and alarming.

In 1828 the 24-foot contour was the dominating curve of the anchorage. Coming down from the cape, it left the shore near the head of the present iron pier, bending northeast for 2,000 feet, and thence curving to the west-northwest through the middle of the harbor. In 1877 the 24-foot curve has nearly disappeared. With the exception of a small area south of the ice-breaker, maintained by the currents through the gap, and of a deep excavation near the eastern end of the breakwater, due to the inrush of the flood, the 24-foot basin has shrunk to a narrow area, half a mile long and 200 or 300 feet wide, in the eastern portion of the harbor, still clinging tenaciously to its position near the pier, but evidently in rapid process of obliteration from the closing together of its margins.

The 18-foot curve, which in 1828 occupied a relatively unimportant space in the southwest, has in 1877 become the controlling feature. One branch, leaving the west end of the breakwater and dipping slightly to avoid the gap, passes west with a northerly inclination; the other branch, starting from the same point, and following the foot of the breakwater for two-thirds its length, bends southwest to a point 1,200 feet west of the pier, and thence goes eastwardly. Between these two branches, which include the greater as well as the most valuable part of the anchorage, is now found on an average but 16 feet of water, with a yearly decreasing depth.

This decrease is not chiefly, nor even in any great degree, due to the extension of the shoal near the breakwater light. This shoal began to form contemporaneously with the construction of the breakwater, and, protected from both ebb and flood tides, has continued to grow ever since. But in October, 1843, Major Bache refers to this shoal as the "only one from which any evil effects have arisen"; states that although it had continued gradually to increase since attracting attention in 1834, its rate of increase was decreasing, and expresses the hope that its ultimate development had been attained.

It appears that this hope was measurably justified, since in 1863 the 18-foot curve embracing this shoal had not greatly increased in extent; but the advance from the southwest of the opposite 18-foot curve had at this time enabled it to effect a junction with the shoal, followed by its wide separation into the two branches shown in 1877.

This union took place about 1861 or 1862, 200 or 300 feet outside the

24-foot curve of 1828, as is evidenced by the peculiar disposition of the red curves at this point. Had the "gap" between the ice-breaker and the breakwater been closed at any time previous to 1863, so as to compel the full flow of the ebb to traverse the harbor, this union could not have occurred, and the shoal under the breakwater would not probably have extended beyond a line drawn through the west end of the ice-breaker parallel to the breakwater. Were the gap now to be closed, it is more than likely that the shoal area would again be divided. It is certain that a considerable increase in depth would almost immediately follow.

The project of closing the gap has often been considered and frequently recommended, but mainly with reference to the increasing demand for additional protection and harbor space.

Of the great desirability and even necessity of so doing I can see no room for doubt. It would at once double the barrier against the north-east gales, quadruple the available area, and materially increase the depth of the anchorage, besides tending to repress the encroachments at the cape.

The principal objection urged against a complete closure has been the supposed danger attending further interference with the currents.

Since in the absence of such interference a marked determination has taken place and is still progressing, it would appear that an active interposition is now imperatively demanded.

The real source of peril, however, lies in the formidable shoaling coming from the southwest, shown by the rapid advance of the contours, and against this certain danger the remedies hitherto proposed would be of little effect.

The 15-foot curve of 1877, shown on the chart, is about to occupy the position of the 18-foot curve of 1842. A few years later, and it cannot be doubted that it will have inclosed the area now embraced by the 18-foot curve of 1877, with the 12-foot curve pressing on in rear.

The accumulation of material in the upper part of the harbor is attributable to causes similar to those at the cape (though opposite in direction), and, like them, acting in part independently of the works.

To the westward the shore line of the bay curves gradually to the north-west and north-northwest, and down this shore the winds from the north-west quadrant at times the severest that blow in the bay, sweep unobstructed, and strongly agitating the shoal water adjacent to the beach, aid the ebb tides to drive the sands and mud along the bottom.

Since the ebb tides must to a certain extent preponderate, any wind sufficient in force to stir the bottom will add its effect, and the consequence is the gradual transfer of material to the southward, and its accumulation in the concavity in front of Lewes.

Previous to the construction of the breakwater the flood tides, enjoying freer entrance, and the northeast winds acting with unrestricted force, sufficed to maintain the equilibrium which gave the anchorage its former regimen, but under cover of the works this accumulation has been enabled to creep down towards the cape.

These movements along the bottom take place mainly between the 18-foot curve and the shore. At greater depths it is probable that the wave action is not sufficient to loosen the sticky bottom.

It remains to consider the remedies that should be applied.

If I am right in my interpretation of the observed phenomena, it will be necessary to arrest absolutely the shoaling from the westward by constructing a continuous jetty from high water mark out to at least,

the present 15-foot curve. As a compromise between cost and space secured, the jetty might commence at a point about 300 yards west of the present railroad pier, near the site of the old United States pier, and extend towards a point on the line of the ice-breaker prolonged westward its own length. The direction of this line would be about N. by E. $\frac{1}{2}$ E.

At the same time, the gap should be closed by connecting the west end of the breakwater with the east end of the ice-breaker, first laying a floor of rock along the whole line to avoid excavations, and afterwards adopting a modified profile, and using dimension stone, as recommended by General Barnard in 1853. The cost of this project he estimated then at \$500,000. It should not exceed that sum now.

The logical completion of this project contemplates a prolongation of both jetty and ice-breaker to a common point, and consequently the eventual transformation of the harbor into a closed basin, with a single entrance from the cape, through which the tides should ebb and flow, and with an area of about one square mile; but it is believed that for many years to come the flow of the tides between the jetty and the ice-breaker would be attended with no other ill effects than the admission of ice into the harbor and a shoaling at the inner angle of the jetty, not greater, however, than is now going on.

The jetty, being protected from all easterly winds, and evading the full force of north-northwest gales by its direction, need not be constructed of stone, but much more cheaply of two parallel rows of 12-inch by 12-inch timber piling, thoroughly creosoted as protection against the worm, and sunk solidly into the bottom by aid of the water-jet. The two rows to be 10 feet apart, the piles in close contact, and the joints made tight, either with battens on the inside or more efficaciously by 2-inch by 3-inch tongue-pieces driven into central grooves cut out of the adjoining piles. Each pair of piles to be connected by cross-pieces, and the space between filled with sand or other material. Such a construction should not cost to exceed \$75 per foot run.

Without going into details, and accepting General Barnard's estimate of \$500,000 for closing the gap, a like amount would prolong the ice-breaker westward its own length, and \$1,000,000 more should connect it with the shore. In other words, \$2,000,000, an amount less than the cost of the present imperfect works, would suffice to construct this basin sufficient in capacity to contain half the vessels engaged in the coasting trade of the United States, and which a tax upon tonnage so small as not to be felt would thereafter maintain.

The alternative of some project such as this for the improvement and perfection of the Breakwater Harbor is the construction of a new harbor in another position. The natural basin formed by the "Shears," about 2 miles northwest of the ice-breaker, suggests itself as suitable for this purpose, and possesses great and undoubted advantages therefor; but the cost of forming a harbor here would be very heavy, at least three or four times as great as that of the works now suggested, and in this case as well the logical outcome would be the eventual construction of a closed basin.

The utility of the Breakwater Harbor has been repeatedly illustrated and explained in previous reports. I shall not, therefore, insist upon so obvious a fact, further than to say that during any heavy storm the vessels seeking its shelter would, with their cargoes, equal in value half its entire cost.

For the arrest of the movement of the cape, it will probably suffice to construct small jetties perpendicular to the shore, and at sufficiently short

intervals to enable them to render mutual aid. These could be constructed of double rows of heavy stakes, driven in and wired together at the top, and the intervals filled with brush. The material can be obtained close at hand from the pine forests of the cape, and the jetties would cost little more than the labor.

The suggested modifications of the present works are shown upon the chart in dotted lines.

I am, colonel, very respectfully, your obedient servant,

WILLIAM LUDLOW,

Captain of Engineers.

Col. J. N. MACOMB,

Corps of Engineers, U. S. A.

P. S.—It will be seen from the above report that the newspaper article, though probably written with the praiseworthy object of attracting attention to the perilous condition of the harbor, goes far beyond the true facts of the case, and loses in force by numerous misstatements and erroneous inferences, among others the following :

Since this work [the Delaware Breakwater] was finished the point of the cape has extended between 700 and 800 yards due north.

The breakwater was completed in 1869. Mr. Rodney attributes to the cape an advance of 100 yards annually. Its actual advance has been 800 feet in 50 years, or an average of 16 feet per year.

The point of the cape is not now 400 yards beyond the new beacon. It is only half that distance.

It is not at all impossible for a square-rigged vessel to enter the harbor from the cape during a southeast gale. I saw them do so last summer.

The course from the cape to the inner harbor is due west. This course puts a southeast wind on the vessel's quarter, than which, it is needless to say, nothing could be more favorable. Even with a gale from the south, a square-rigged vessel could make the harbor from the cape. As a matter of fact, square-rigged vessels seldom enter the inner harbor from any direction, and for two reasons, viz, the depth of water is insufficient and the harbor in stormy weather is full of small vessels. Referring to the injury to the harbor occasioned by the gap, Mr. Rodney says that the depth through this opening has increased from $3\frac{1}{2}$ fathoms to 12 fathoms; an increase of 51 feet.

By the survey of 1828 the average depth was originally 27 feet. It is now about 31 feet; an increase of 4 feet only. On the margin of the deep excavation north of the breakwater light the depth exceeds this; but even here a vessel entering the gap drawing 30 feet of water would bring up on the line of the south side of the breakwater prolonged.

The "shoal reaching to the shore" has been discussed in my report. It has 16 feet upon it instead of 12, as the article states.

The iron pier constructing by the government stands upon piles 8 inches in diameter and 21 feet apart. It has, of course, had no effect whatever upon the harbor, unless slightly to deepen the water in its immediate vicinity, and has cost \$100,000 less than he says.

The vessels lost during recent gales were compelled, for want of space, to anchor beyond the shelter of the works. The writer omits to say that although 12 vessels might be lost, 150 others, worth \$1,000,000, were enabled to ride out the gale in safety.

Were Mr. Rodney's assertions to be accepted as literally true, no captain of a vessel larger than a fishing-smack would attempt to enter the harbor, and he only by daylight and in fair weather.

Giving the author credit for sincerity of purpose, such loose and extravagant statements only prejudice the cause they seek to aid, from the natural reaction that ensues upon a discovery of their unreliability. The actual condition of things at the Breakwater Harbor is sufficiently threatening to excite alarm without the publication of sensational articles, calculated, if of any effect, to impair the already reduced usefulness of a great national work.

Respectfully,

WM. LUDLOW,
United States Engineers.

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